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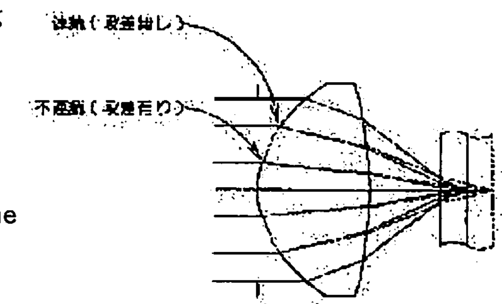
## (54) OBJECTIVE LENS FOR RECORDING AND REPRODUCING OPTICAL INFORMATION RECORDING MEDIUM

(57)Abstract:

PROBLEM TO BE SOLVED: To provide an information pickup device and an optical disk device which are compatible with each other, simple in structure, and compact by enabling one pickup to record and reproduce optical disks having different thickness and suppressing the light quantity loss as much as possible.



SOLUTION: The objective lens for recording and reproduction which has positive refracting power and converges light from a light source on an information recording surface through the transparent substrate of an optical information recording medium has at least one lens surface composed of ≥3 ring-shaped lens surfaces having their centers on the optical axis, adjacent ring-shaped lens surfaces among the ≥3 ring-shaped lens surfaces are different in refracting power, and the ring-shaped lens surface positioned at the outermost periphery has a refracting power corrsponding to the optical information recording medium having the thinnest transparent substrate among plural optical information recording media having transparent substrates differing in thickness, so that the light is converged on the information recording surfaces of the respective optical information recording media having the transparent substrates differing in thickness.

## LEGAL STATUS

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CLAIMS

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[Claim(s)]
[Claim 1] In an objective lens which has positive refractive power which condenses light from the light source on an information recording surface through a transparence substrate of an optical information record medium This objective lens so that it may condense on an information recording surface about each of two or more kinds of optical information record media which has a transparence substrate with which thickness differs one [ at least ] lens side constitutes according to three or more zona-orbicularis-like lens sides centering on an optical axis -- having -- **** -- this -- among three or more zona-orbicularis-like lens sides, while a ****** zona-orbicularis-like lens side has different refractive power A zona-orbicularis-like lens side located in the outermost periphery is the objective lens for record playback of an optical information record medium characterized by having refractive power corresponding to an optical information record medium with thinnest transparence substrate among two or more optical information record media which have a transparence substrate with which the above-mentioned thickness differs.
[Claim 2] It sets to a rectangular coordinate system which this aspheric surface configuration made top-most vertices of a field a zero, and set the X-axis as the direction of an optical axis by the above-mentioned objective lens's being a positive single lens which turned a convex to a light source side, and both sides facing a light source and information recording surface side being the aspheric surfaces, and forming a zona orbicularis-like lens side in a field by the side of the light source at least, and they are a cone number and Ai about kappa. An aspheric surface coefficient and Pi When considering as the number of **** of the aspheric surface [Equation 1]

$$x=\frac{C\phi^{2}}{1+\sqrt{1-(1+\kappa)C^{2}\phi^{2}}}+\Sigma A i\,\phi^{Pi}$$

$$\phi=\sqrt{y^{2}+z^{2}}\quad,\qquad C=1/r$$

the objective lens of the optical information record medium of claim 1 characterize by optical path length difference ** of the thickness of a lens and the light source wavelength lambda on the shaft at the time of having come out, and be express and even an optical axis extend the configuration of each zona orbicularis-like lens side corresponding to the same transparence substrate according to the above-mentioned aspheric surface configuration type satisfy the following relation for record playback.
** = mlambda (m is an integer)
however, **: -- the wavelength of the light source which applied the refractive index of this lens in operating wavelength to the difference of the thickness of the lens on a shaft when even an optical axis extends the configuration of two zona orbicularis of the arbitration of each zona-orbicularis-like lens side corresponding to the same transparence substrate according to the above-mentioned aspheric surface configuration type and of which value lambda:use is done [Claim 3] An objective lens for record playback of an optical information record medium of claim 2 with which the above-mentioned optical-path-length difference is characterized by satisfying the following relation.
- 10 <= M <= 10 [Claim 4] Three or more zona-orbicularis-like lens sides of the above-mentioned objective lens So that it may condense on an information recording surface about each of two kinds of optical information record media which has a transparence substrate with which thickness differs

Claim 1 characterized by establishing a zona-orbicularis-like lens side corresponding to a transparence substrate with thin thickness, and a zona-orbicularis-like lens side corresponding to a transparence substrate with thick thickness by turns in this sequence from a periphery thru/or an objective lens for record playback of which optical information record medium of 3.
[Claim 5] an objective lens for record playback of an optical information record medium of claim 2 characterized by a transparence substrate of the above-mentioned two or more classes being alike, respectively, and a configuration of each zona-orbicularis-like lens side of corresponding being able to express by the same aspheric surface configuration formula.
[Claim 6] Claim 2 to which an angle of each **** and optical axis of outside zona-orbicularis-like lens each one in a boundary portion of an adjoining zona-orbicularis-like lens side and inside zona-orbicularis-like lens each one to make is characterized by filling the following conditional expression in a lens side by the side of the light source which has a zona-orbicularis-like lens side of the above-mentioned objective lens, or an objective lens for record playback of which optical information record medium of 5.
theta (2i-1) > theta' (2i) [1 <=i<=N/2 and i are integer].
theta (2j) < -- theta' (2j+1) [1<=j<= (N-1)/2 and j -- integer]
However, N : the number theta of zona-orbicularis-like lens sides of a lens side by the side of the light source of an objective lens (2i-1) It is the angle of a normal of a ** (2i-1) zona-orbicularis-like lens side and an optical axis in a boundary portion of 2 i flower band-like lens side to make. the [ a :** (2i-1) zona-orbicularis-like lens side and ] -- a ** (2i-1) zona-orbicularis-like lens side -- the -- it is located outside 2 i flower band-like lens side (a circumference side).
theta' (2i) : -- the [ a ** (2i-1) zona-orbicularis-like lens side and ] -- the [ in a boundary portion of 2 i flower band-like lens side ] -- an angle of a normal of 2i zona-orbicularis side, and an optical axis to make -- it is -- the -- 2 i flower band-like lens side is located inside a ** (2i-1) zona-orbicularis-like lens side (an optical-axis side).
theta (2j) : -- the -- the [ in boundary portions of 2 j flower band-like lens side and a ** (2j+1) zona-orbicularis-like lens side ] -- an angle of a normal of 2 j flower band-like lens side, and an optical axis to make -- it is -- the -- 2 j flower band-like lens side is located outside a ** (2j+1) zona-orbicularis-like lens side (a circumference side).
theta'(2j+1): -- the -- an angle of a normal of a ** (2j+1) zona-orbicularis-like lens side and an optical axis in boundary portions of 2 j flower band-like lens side and a ** (2j+1) zona-orbicularis-like lens side to make -- it is -- a ** (2j+1) zona-orbicularis-like lens side -- the -- it is located inside 2 j flower band-like lens side (an optical-axis side).
[Claim 7] An objective lens for record playback of an optical information record medium of claim 6 characterized by setting up a boundary of an outermost periphery zona-orbicularis-like lens side and a zona-orbicularis-like lens side of the one inside so that the following conditional expression may be satisfied.
1.50 < -- Lambda/NA 2 < -- 2.00 -- however -- Lambda : Wavelength (Micrometer) of the Light Source to be Used
NA2 : Numerical aperture of the flux of light which carries out outgoing radiation from a zona-orbicularis-like lens side inside [ one ] the outermost periphery [Claim 8] A material which forms the above-mentioned objective lens is the objective lens for record playback of claim 1 characterized by being glass thru/or which optical information record medium of 7.
[Claim 9] A material which forms the above-mentioned objective lens is the objective lens for record playback of claim 1 characterized by being plastics thru/or which optical information record medium of 7.
[Claim 10] One place of a boundary portion between each zona-orbicularis-like lens side is the objective lens for record playback of claim 8 which there is no level difference and is characterized by being continuation, or an optical information record medium of 9.
[Claim 11] An objective lens for record playback of an optical information record medium of claim 10 characterized by the number N of zona orbicularis formed in a lens side by the side of the light source of the above-mentioned objective lens satisfying the following conditional expression.
3<=N<=10 [Claim 12] An objective lens for record playback of an optical information record medium of claim 10 characterized by the number N of zona orbicularis formed in a lens side by the side of the light source of the above-mentioned objective lens satisfying the following conditional

expression.
3<=N<=6

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[Translation done.]

* NOTICES *



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DETAILED DESCRIPTION

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[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the objective lens used for the optical system which carries out record playback of the information by condensing the light beam from the light sources, such as a laser beam, to an information recording surface through a transparence substrate.
[0002]
[Description of the Prior Art] An example of the optical system for record playback of the conventional optical information record medium (with the optical system for record playback as used in the field of this invention, the optical system for record, the optical system for playback, and the optical system both for record and playback are included.) is shown in drawing 8 . In drawing, incidence of the flux of light which carried out outgoing radiation from the light sources 1, such as semiconductor laser, is carried out to a collimator lens 3 through a beam splitter 2, and it turns into the parallel flux of light, is extracted, is restricted to the flux of light predetermined by 5, and carries out incidence to an objective lens 6. If the parallel flux of light carries out incidence of this objective lens 6, it will carry out image formation of the optical spot of non-aberration on the information recording surface 8 mostly through the transparence substrate 7 of predetermined thickness. It separates into a beam splitter 2 from the optical path from a laser light source 1 through an objective lens 6 and a collimator lens 3 return and here, and incidence of the flux of light which the information pit became irregular and was reflected by this information recording surface 8 is carried out to the light-receiving means 9. This light-receiving means 9 is the PIN photodiode by which hyperfractionation was carried out, it outputs the current which is proportional to the reinforcement of incoming beams from each element, controls an objective lens 6 by the two-dimensional actuator constituted from a magnetic circuit, a coil, etc. by the detector system which does not show this current in drawing delivery and here based on an information signal, a focal error signal, and a truck error signal, and always doubles an optical spot location on a code track.
[0003] In such information pickup, since it is Size NA (for example, NA0.6) in order to make small the optical spot condensed with an objective lens 6, if the thickness of the transparence substrate placed into such the condensing flux of light shifts from predetermined thickness, big spherical aberration will be generated. With the objective lens optimized with reference to drawing 9 on condition that the wavelength of 635nm of the laser beam by which outgoing radiation is carried out from NA 0.6 and a laser light source, the transparence substrate thickness of 0.6mm, and the substrate refractive index 1.58, when the thickness of a substrate is changed, whenever 0.01mm substrate thickness shifts, in 0.01lambdarms, aberration increases. Therefore, the MARESHARU threshold value which will serve as aberration of 0.07lambdarms if transparence substrate thickness shifts **0.07mm, and serves as a standard which can read normally will be reached. For this reason, when it is going to carry out record playback of the optical information record medium which changes to the substrate of 0.6mm thickness, for example, has the substrate of 1.2mm thickness, it extracts as the objective lens 11 corresponding to 1.2mm thickness in the actuator section, and he switches to 10, and is trying to reproduce. Or equipping two information pickup, the object for the substrates of 0.6mm thickness and the object for the substrates of 1.2mm thickness, is also considered. Moreover, a hologram is arranged during information pickup and the method of making an information recording surface condense each of the zero-order light which passes this, and

primary light as an optical spot corresponding to 0.6mm thickness substrate and 1.2mm thickness substrate is also considered.
[0004] In order to use as refreshable equipment the optical disk which has substrate thickness which is different as mentioned above with one optical disk unit, transparence substrate thickness of a disk cannot attach two matched-pairs object lenses in each business 1.2mm with the object for 0.6mm, or cannot make an information pickup and an optical disk unit that it is compact and low cost by the way the transparence substrate thickness of a disk attaches two optical pickups, the object for 0.6mm, and the object for 1.2mm, to equipment. Moreover, the zero-order light which arranges a hologram during information pickup and penetrates this, The method of making an information recording surface condensing each of primary light as an optical spot corresponding to 0.6mm thickness substrate and 1.2mm thickness substrate Since outgoing radiation of the two flux of lights is always carried out towards an information recording surface, when performing information read-out by the optical spot by one flux of light, the flux of light of another side not only serves as unnecessary light which does not contribute to read-out, but The diffracted light which cannot be used besides two actually used spots occurs, quantity of light loss is large, and the S/N ratio fall by quantity of light fall, and when increasing the quantity of light, a laser life will fall.
[0005]
[Problem(s) to be Solved by the Invention] This invention cancels the above-mentioned defect, enables record playback of the optical disk which has substrate thickness which is different by one pickup, and aims at obtaining the objective lens for record playback of the optical information record medium which makes it possible to realize the information pickup easy [ structure ] and compact which has compatibility in mutual [ which suppressed quantity of light loss as much as possible ], and an optical disk unit.
[0006]
[Means for Solving the Problem] An objective lens for record playback of an optical information record medium of this invention It is the objective lens which has positive refractive power which condenses light from the light source on an information recording surface through a transparence substrate of an optical information record medium. This objective lens so that it may condense on an information recording surface about each of two or more kinds of optical information record media which has a transparence substrate with which thickness differs one [ at least ] lens side constitutes according to three or more zona-orbicularis-like lens sides centering on an optical axis -- having -- **** -- this -- among three or more zona-orbicularis-like lens sides, while a ****** zona-orbicularis-like lens side has different refractive power A zona-orbicularis-like lens side located in the outermost periphery is characterized by having refractive power corresponding to an optical information record medium with thinnest transparence substrate among two or more optical information record media which have a transparence substrate with which the above-mentioned thickness differs.
[0007] The above-mentioned objective lens is more specifically a positive single lens which turned a convex to a light source side. In a rectangular coordinate system which both sides facing a light source and information recording surface side are the aspheric surfaces, and a zona-orbicularis-like lens side is formed in a field by the side of the light source at least, and this aspheric surface configuration made top-most vertices of a field a zero, and set the X-axis as the direction of an optical axis They are a cone number and Ai about kappa. An aspheric surface coefficient and Pi It is [Equation 2] when considering as the number of **** of the aspheric surface.

$$x=\frac{C\phi^2}{1+\sqrt{1-(1+\kappa)C^2\phi^2}}+\Sigma Ai\,\phi^{Pi} \quad \cdots ①$$

$$\phi=\sqrt{y^2+z^2} \quad , \quad C=1/r$$

It comes out, and it is expressed and optical-path-length difference ** of the thickness of a lens and the light source wavelength lambda on the shaft at the time of even an optical axis extending the configuration of each zona-orbicularis-like lens side corresponding to the same transparence substrate according to the above-mentioned aspheric surface configuration type satisfy the following relation.
** = mlambda ... **[ **, however ]: When even an optical axis extends the configuration of two

zona-orbicularis-like lens sides of the arbitration of each zona-orbicularis-like lens side corresponding to the same transparence substrate according to the above-mentioned aspheric surface configuration type the wavelength of the light source which multiplied the difference of the thickness of the lens on **** by the refractive index of this lens in operating wavelength and of which value lambda:use is done -- m is an integer here and the more desirable thing which optical-path-length-differences are the following ranges is desirable.
- 10 <= m <= 10 ... It is desirable for the configuration of ** and each zona-orbicularis-like lens side corresponding to the same above-mentioned transparence substrate to be able to express by the same aspheric surface configuration formula.
[0008] In the lens side by the side of the light source which makes the zona-orbicularis-like lens side configuration of the above-mentioned objective lens, it is desirable for the angle of each **** and optical axis of outside zona-orbicularis-like lens each one in the boundary portion of an adjoining zona-orbicularis-like lens side and inside zona-orbicularis-like lens each one to make to fill the following conditional expression.
theta (2i-1) > theta' (2i) [ -- 1 <=i<=N/2 and i -- integer] ... ** theta (2j) < -- theta' (2j+1) [1<=j<= (N-1)/2 and j -- integer ]-** -- however, N : the number theta of zona-orbicularis-like lens sides of the lens side by the side of the light source of an objective lens (2i-1) It is the angle of the normal of a ** (2i-1) zona-orbicularis-like lens side and optical axis in the boundary portion of 2 i flower band-like lens side to make. the [ a :** (2i-1) zona-orbicularis-like lens side and ] -- a ** (2i-1) zona-orbicularis-like lens side -- the -- it is located outside 2 i flower band-like lens side (circumference side).
theta' (2i) : -- the [ a ** (2i-1) zona-orbicularis-like lens side and ] -- the [ in the boundary portion of 2 i flower band-like lens side ] -- the angle of the normal of 2i zona-orbicularis side, and an optical axis to make -- it is -- the -- 2 i flower band-like lens side is located inside a ** (2i-1) zona-orbicularis-like lens side (optical-axis side).
theta (2j) : -- the -- the [ in the boundary portions of 2 j flower band-like lens side and a ** (2j+1) zona-orbicularis-like lens side ] -- the angle of the normal of 2 j flower band-like lens side, and an optical axis to make -- it is -- the -- 2 j flower band-like lens side is located outside a ** (2j+1) zona-orbicularis-like lens side (circumference side).
theta'(2j+1): -- the -- the angle of the normal of a ** (2j+1) zona-orbicularis-like lens side and optical axis in the boundary portions of 2 j flower band-like lens side and a ** (2j+1) zona-orbicularis-like lens side to make -- it is -- a ** (2j+1) zona-orbicularis-like lens side -- the -- it is located inside 2 j flower band-like lens side (optical-axis side).
[0009] As for the above-mentioned objective lens, it is still more desirable that the boundary of an outermost periphery zona-orbicularis-like lens side and the zona-orbicularis-like lens side of the one inside is set up so that the following conditional expression may be satisfied.
1.50 < -- Lambda/NA 2 < -- 2.00 ... ** -- however -- Lambda : Wavelength (Micrometer) of Light Source to be Used
NA2 : several zona orbicularis desirable [ it ] and formed [ one place of the numerical aperture of the flux of light which carries out outgoing radiation from the zona-orbicularis-like lens side inside / one / the outermost periphery, and the boundary portion between each zona-orbicularis-like lens side did not have a level difference, and ] in the lens side by the side of the light source -- N -- 3<=N<=10 ... -- ** -- further -- desirable -- 3<=N<=6 ... -- it is desirable that it is in the range of **
[0010] The material which forms the above-mentioned objective lens may be glass, or may be plastics.
[0011]
[Function] The objective lens for record playback of the optical information record medium of this invention enables record playback of the optical disk with which the thickness of a transparence substrate differs, when one [ at least ] lens side consists of zona orbicularis which has the refractive power from which a ****** zona-orbicularis-like lens side differs and condenses the flux of light on each information recording surface through the transparence substrate with which the thickness of an optical information record medium differs. When the parallel flux of light with a wavelength of 635nm carries out incidence of drawing_3 on condition that NA 0.60, 0.6mm of substrate thickness, and the substrate refractive index 1.58, it is optical-path drawing when carrying out incidence of the

flux of light to the objective lens with which aberration amendment was optimized. When the parallel flux of light with a wavelength of 635nm carries out incidence of drawing 4 on condition that NA 0.38, 1.2mm of substrate thickness, and the substrate refractive index 1.58, it is optical-path drawing when carrying out incidence of the flux of light to the objective lens with which aberration amendment was optimized. Drawing 5 is optical-path drawing when carrying out incidence of the flux of light to the objective lens which has the refracting interface of the shape of zona orbicularis which has drawing 3 and two conditions in 4. After the flux of light from infinite distance passes drawing, incidence of it is carried out to the objective lens which has a zona-orbicularis-like lens side. It is divided into the substrate thickness of 0.6mm, and two spots which condense through 1.2mm by passing through the zona-orbicularis-like lens side where refractive power differs here.
[0012] The outgoing beam from the inside zona orbicularis including an optical axis shows the case where it is constituted so that it may condense through 1.2mm of substrate thickness so that drawing 5 may form in the lens side of an objective lens two zona-orbicularis-like lens sides (only henceforth the zona orbicularis) where refractive power differs and the outgoing beam from the periphery zona orbicularis may condense through 0.6mm of substrate thickness. In the case of this example, the optical intensity distribution of the flux of light which condenses through 0.6mm of substrate thickness and 1.2mm of substrate thickness come to be shown in drawing 6 and 7, respectively. Since the optical spot from the periphery zona orbicularis which condenses through the substrate of 0.6mm of substrate thickness is a spot for making it correspond to high density information record, when the reinforcement of a side lobe as shown in drawing 6 becomes large too much, it causes increase of a noise and a ****** case is in record playback of high density information about a bad influence. Therefore, by considering as the 3rd zona orbicularis which has the refractive power corresponding to 0.6mm of substrate thickness for an inner circumference side including the optical axis of the inner circumference zona-orbicularis section corresponding to 1.2mm of substrate thickness, at the time of 0.6mm of substrate thickness, the area of the 2nd zona orbicularis which carries out outgoing radiation of the unnecessary light can be decreased, and a side lobe can be decreased. It becomes possible to obtain two optical spots suitable for performing record playback of the optical information record medium with which substrate thickness differs by constituting from a periphery two or more zona orbicularis from which the refractive power which repeats this, namely, is prepared in a lens side differs alternately. however, the level which is satisfactory practically in a side lobe since the width of face of the zona orbicularis will become small too much and processability will worsen, if the number of zona orbicularis is increased too much -- mitigating -- in addition -- and in order to keep processability good, it is desirable to make it three or more zona orbicularis and ten zona orbicularis or less. It is desirable to make it three or more zona orbicularis and six zona orbicularis or less still more desirably.
[0013] By making the light source side of an objective lens into a convex, and introducing the aspheric surface into both sides by the side of the light source and an information recording surface further, a single lens can realize an objective lens and cost reduction becomes possible. When the thickness of the lens on the shaft at the time of even an optical axis extending the lens side configuration of each zona orbicularis corresponding to the same transparence substrate according to the above-mentioned ** type is not equal, an optical-path-length difference arises in the flux of light which passes each zona orbicularis. When the wave faces which have an optical-path-length difference overlap, interference occurring is known well, and when the relation of **=mlambda (m is an integer) is materialized between optical-path-length difference ** and wavelength lambda, the reinforcement by interference serves as max. Therefore, when conditional-expression ** is materialized between value ** which applied the refractive index of the lens in operating wavelength to the difference of the thickness of the lens on the shaft at the time of even an optical axis extending the lens side configuration of two zona orbicularis of the arbitration of each zona orbicularis corresponding to each transparence substrate according to the above-mentioned ** type, and the operating wavelength lambda, the optical spot of the maximum reinforcement will be obtained. However, since there is specifically wavelength variation by the light source, the variation by individual difference, and the temperature change in the wavelength of semiconductor laser, it is difficult to fix to fixed wavelength. Therefore, the case where the relation of optical-path-length difference conditional-expression ** collapses from each zona orbicularis to the flux of light arises.

Since it generates about 5%, such wavelength variation is good to satisfy conditional-expression ** more desirably. In this case, even if wavelength variation arises, it is possible to maintain 50% or more of reinforcement of original reinforcement. Furthermore, if it is **=0, it cannot be overemphasized irrespective of wavelength variation that fixed reinforcement is maintainable. Moreover, in order to raise the processability of this zona orbicularis more, it is desirable for the configuration of these zona orbicularis to be able to express by the same aspheric surface configuration formula.

[0014] As a material of an objective lens, it is also possible to use any of glass and plastics. In the case of a glass material, it becomes possible [ realizing low cost further by using a plastics material ], when an engine-performance change the thing with little engine-performance change for which the stable lens is offered is possible, and according to an environmental variation is permissible to an environmental variation.

[0015] When not filling conditional-expression ** and **, the location of the optical spot which condenses through each of a thin transparence substrate and a thick transparence substrate will approach. If the location of two optical spots approaches, the optical reinforcement in the information recording surface of an unnecessary optical spot will become large. Consequently, a big noise will occur and record playback of an optical information record medium becomes difficult.

[0016] This invention tends to realize record playback of the record medium with which the thickness of a transparence substrate differs with a single objective lens in the trend of the recent years of an optical information record medium like the thin high density information record disk of substrate thickness, and the conventional disk. For example, since the disk of 0.6mm of substrate thickness aims at densification, a small optical spot is called for compared with the conventional CD of 1.2mm of substrate thickness, and CD-ROM. Specifically in the conventional CD, CD-ROM, etc., the optical spot whose NA of an objective lens the wavelength of the light source is about 0.45 in 780nm was called for. The magnitude of an optical spot is proportional to wavelength, and it is known well that it is in inverse proportion to NA. Therefore, in order to make an optical spot small, it is necessary to shorten wavelength or to enlarge NA of an objective lens. In the high-density disk of 0.6mm of substrate thickness, while shortening wavelength of the light source to 635nm - about 650nm, it considers making an optical spot small by making NA of an objective lens large to about 0.6.

[0017] In realizing the optical spot corresponding to two kinds of disks from which the thickness of a transparence substrate differs with the objective lens of this invention, 0.6mm of substrate thickness, and 1.2mm of substrate thickness, it distributes to the flux of light for disks of 0.6mm of substrate thickness, and 1.2mm of substrate thickness every other one from the zona orbicularis of the outermost periphery. Therefore, when the wavelength of the light source is 635nm, it is necessary to use as an optical spot equivalent to NA0.6 the flux of light which passed the zona orbicularis of the outermost periphery, and to use as an about (equivalent to about 0.45 NA, when light source wavelength is 780nm) 0.37-NA optical spot the flux of light which passed the zona orbicularis of the one inside. Conditional-expression ** is required in order to fulfill this condition. In fixed light source wavelength, if it becomes so small that the numerical aperture NA2 of the zona orbicularis of the one inside exceeds a maximum from the outermost periphery, an optical spot will become large too much and record playback of the optical information record medium of 1.2mm of substrate thickness will become difficult. Moreover, if numerical aperture NA2 becomes large so that a minimum is exceeded, an optical spot will become small too much and informational record playback will become difficult too.

[0018] the objective lens of this invention has the equal thickness of the lens on the shaft at the time of even an optical axis extending the lens side configuration of each zona orbicularis which two or more kinds of transparence substrates are alike , respectively , and corresponds according to ** type , or when there is a difference , it is setting to one of the features trying for the optical path length difference produce by it to serve as an integral multiple of use light wave length . Moreover, the lens side where refractive power differs is made to adjoin in the shape of zona orbicularis. Therefore, on all the boundaries of the zona orbicularis which recognizes individual (N-1) existence in the lens side which has the zona orbicularis of N individual, it is difficult to make it the continuous field without a level difference. However, if a level difference is in a lens side, since it will become easy to generate

a chip etc. into a level difference portion, in respect of productivity and processability, a level difference is not desirable. Therefore, in order to raise productivity and processability, as for one place of the boundary section between zona orbicularis, it is desirable that it is a field [ **** ] without a level difference.
[0019] Hereafter, the example of the objective lens of this invention is shown. Both the examples 1 and 2 are infinity conjugation mold objective lenses, and the incident light to an objective lens is the parallel flux of light. Moreover, operating wavelength is 635nm. The cross section and optical-path drawing of an example 1 are shown in drawing 1 , and the cross section and optical-path drawing of an example 2 are shown in drawing 2 . Drawing is made into the 1st page in each example, and it is [ radius of curvature / of the i-th field ] ni from here to order about the refractive index in the light source wavelength of the medium between di, the i-th field, and the i+1st fields in the thickness on ri and the i-th optical axis of a field and the i+1st fields, and a gap. It expresses. Moreover, the refractive index of air is set to 1. Moreover, the aspheric surface configuration has written each data with the configuration where even the optical axis extended each zona-orbicularis-like lens side by ** type in the lens side which makes a zona-orbicularis configuration.
[0020] Example 1 Light source side : Division 3 zona orbicularis (from the periphery of a lens side to the 1st, 2nd, and 3rd zona orbicularis)
The zona-orbicularis [ 1st ] outside diameter: 4.08 The 1st zona-orbicularis numerical aperture NA 1:0.60 The zona-orbicularis [ 2nd ] outside diameter: 2.84 The 2nd zona-orbicularis numerical aperture NA 2:0.38 The zona-orbicularis [ 3rd ] outside diameter: 1.20 The 3rd zona-orbicularis numerical aperture NA 3:0.18 Disk side: The 1st and 3rd zona orbicularis of community (thin substrate correspondence)
i ri di ni 1 Drawing (infinity) 0.00 1.00 2 2.062 2.60 1.49005 3 -5.078 1.61 1.00 4 infinity 0.60 1.58000 Five recording surfaces (infinity)
The 2nd zona orbicularis (thick substrate correspondence)
i ri di ni 1 Drawing (infinity) 0.0627 1.00 2 2.340 2.5373 1.49005 3 -5.078 1.61 1.00 4 infinity 1.20 1.58000 5 Recording surface (infinity)
Aspheric surface data The 2nd page The 1st and 3rd zona orbicularis kappa = [ -0.83962 ] A1 = 0.44559x10-2 P1= 4.0000 A2 = 0.23840x10-3 P2= 6.0000 A3 = 0.66596x10-5 P3= 8.0000 A4 =-0.77995x10-5 P4=10.0000 The 2nd zona orbicularis kappa = [ -0.58070 ] A1 = 0.18785x10-2 P1= 4.0000 A2 =-0.15721x10-5 P2= 6.0000 A3 =-0.49050x10-4 P3= 8.0000 A4= 0.36035x10-5 P4=10.0000 The 3rd page kappa =-0.17696x102 A1 = 0.99680x10-2 P1= 4.0000 A2 =-0.44437x10-2 P2= 6.0000 A3 = 0.92652x10-3 P3= 8.0000 A4 =-0.81284x10-4 P4=10.0000 Angle which a normal and an optical axis make theta 1 = 37.8 degrees theta2'=34.1 degree theta2 =14.7 degree theta3'=16.5 degree[0021] Example 2 Light source side : Division 5 zona orbicularis (the 1st from the periphery of a lens side, the 2nd, the 3rd, the 4th, the 5th zona orbicularis)
The zona-orbicularis [ 1st ] outside diameter: 4.08 The 1st zona-orbicularis numerical aperture NA 1:0.60 The zona-orbicularis [ 2nd ] outside diameter: 2.84 The 2nd zona-orbicularis numerical aperture NA 2:0.38 The zona-orbicularis [ 3rd ] outside diameter: 2.20 The 3rd zona-orbicularis numerical aperture NA 3:0.32 The zona-orbicularis [ 4th ] outside diameter: 1.20 The 1st zona-orbicularis numerical aperture NA 1:0.16 The zona-orbicularis [ 5th ] outside diameter: 0.70 The 2nd zona-orbicularis numerical aperture NA 2:0.10 Disk side: The 1st, 3rd, and 5th zona orbicularis of community (thin substrate correspondence)
i ri di ni 1 Drawing (infinity) 0.00 1.00 2 2.062 2.60 1.49005 3 -5.078 1.61 1.00 4 infinity 0.60 1.58000 Five recording surfaces (infinity)
The 2nd and 4th zona orbicularis (thick substrate correspondence)
i ri di ni 1 Drawing (infinity) 0.0627 1.00 2 2.340 2.5373 1.49005 3 -5.078 1.61 1.00 4 infinity 1.20 1.58000 5 Recording surface (infinity)
Aspheric surface data The 2nd page The 1st, 3rd, and 5th zona orbicularis kappa = [ -0.83962 ] A1 = 0.44559x10-2 P1= 4.0000 A2 = 0.23840x10-3 P2= 6.0000 A3 = 0.66596x10-5 P3= 8.0000 A4 =-0.77995x10-5 P4=10.0000 The 2nd and 4th zona orbicularis kappa=-0.58070 A1 = 0.18785x10-2 P1= 4.0000 A2 =-0.15721x10-5 P2= 6.0000 A3 =-0.49050x10-4 P3= 8.0000 A4= 0.36035x10-5 P4=10.0000 The 3rd page kappa =-0.17696x102 A1 = 0.99680x10-2 P1= 4.0000 A2 =-0.44437x10-2 P2= 6.0000 A3 = 0.92652x10-3 P3= 8.0000 A4 =-0.81284x10-4 P4=10.0000 Angle which a

normal and an optical axis make theta 1 = [ 37.8 degrees ] theta2'=34.1 degree theta2 =26.7 degree theta3'=29.8 degreetheta3 = 16.5 degrees theta4'=14.7degree theta4 = 8.6degree theta5'= 9.7 degrees
[0022]
[Effect of the Invention] The objective lens of this invention enables record playback of the optical disk which has substrate thickness which is different by one pickup, and it makes it possible to realize the information pickup easy [ structure ] and compact which has compatibility in mutual [ which suppressed quantity of light loss as much as possible ], and an optical disk unit. Although other flux of lights serve as unnecessary light which does not contribute to read-out when performing information read-out by the optical spot by the one flux of light since outgoing radiation of two or more flux of lights is always carried out towards an information recording surface There is no defect that the diffracted light which cannot be used besides the spot light actually used like although the hologram was arranged occurs. For this reason, greatly, the S/N ratio fall by quantity of light fall, and when increasing the quantity of light, the defect that a laser life will fall was also able to cancel quantity of light loss.

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[Translation done.]

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TECHNICAL FIELD

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[Industrial Application] This invention relates to the objective lens used for the optical system which carries out record playback of the information by condensing the light beam from the light sources, such as a laser beam, to an information recording surface through a transparence substrate.

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[Translation done.]

* NOTICES *



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PRIOR ART

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[Description of the Prior Art] An optical-system (with optical system for record playback as used in the field of this invention, optical-system for record, optical-system for playback, and optical system both for record and playback are included.) example for record playback of the conventional optical information record medium is shown in drawing 8 . In drawing, incidence of the flux of light which carried out outgoing radiation from the light sources 1, such as semiconductor laser, is carried out to a collimator lens 3 through a beam splitter 2, and it turns into the parallel flux of light, is extracted, is restricted to the flux of light predetermined by 5, and carries out incidence to an objective lens 6. If the parallel flux of light carries out incidence of this objective lens 6, it will carry out image formation of the optical spot of non-aberration on the information recording surface 8 mostly through the transparence substrate 7 of predetermined thickness. It separates into a beam splitter 2 from the optical path from a laser light source 1 through an objective lens 6 and a collimator lens 3 return and here, and incidence of the flux of light which the information pit became irregular and was reflected by this information recording surface 8 is carried out to the light-receiving means 9. This light-receiving means 9 is the PIN photodiode by which hyperfractionation was carried out, it outputs the current which is proportional to the reinforcement of incoming beams from each element, controls an objective lens 6 by the two-dimensional actuator constituted from a magnetic circuit, a coil, etc. by the detector system which does not show this current in drawing delivery and here based on an information signal, a focal error signal, and a truck error signal, and always doubles an optical spot location on a code track.
[0003] In such information pickup, since it is Size NA (for example, NA0.6) in order to make small the optical spot condensed with an objective lens 6, if the thickness of the transparence substrate placed into such the condensing flux of light shifts from predetermined thickness, big spherical aberration will be generated. With the objective lens optimized with reference to drawing 9 on condition that the wavelength of 635nm of the laser beam by which outgoing radiation is carried out from NA 0.6 and a laser light source, the transparence substrate thickness of 0.6mm, and the substrate refractive index 1.58, when the thickness of a substrate is changed, whenever 0.01mm substrate thickness shifts, in 0.01lambdarms, aberration increases. Therefore, the MARESHARU threshold value which will serve as aberration of 0.07lambdarms if transparence substrate thickness shifts **0.07mm, and serves as a standard which can read normally will be reached. For this reason, when it is going to carry out record playback of the optical information record medium which changes to the substrate of 0.6mm thickness, for example, has the substrate of 1.2mm thickness, it extracts as the objective lens 11 corresponding to 1.2mm thickness in the actuator section, and he switches to 10, and is trying to reproduce. Or equipping two information pickup, the object for the substrates of 0.6mm thickness and the object for the substrates of 1.2mm thickness, is also considered. Moreover, a hologram is arranged during information pickup and the method of making an information recording surface condense each of the zero-order light which passes this, and primary light as an optical spot corresponding to 0.6mm thickness substrate and 1.2mm thickness substrate is also considered.
[0004] In order to use as refreshable equipment the optical disk which has substrate thickness which is different as mentioned above with one optical disk unit, transparence substrate thickness of a disk cannot attach two matched-pairs object lenses in each business 1.2mm with the object for 0.6mm, or cannot make an information pickup and an optical disk unit that it is compact and low cost by the

way the transparence substrate thickness of a disk attaches two optical pickups, the object for 0.6mm, and the object for 1.2mm, to equipment. Moreover, the zero-order light which arranges a hologram during information pickup and penetrates this, The method of making an information recording surface condensing each of primary light as an optical spot corresponding to 0.6mm thickness substrate and 1.2mm thickness substrate Since outgoing radiation of the two flux of lights is always carried out towards an information recording surface, when performing information read-out by the optical spot by one flux of light, the flux of light of another side not only serves as unnecessary light which does not contribute to read-out, but The diffracted light which cannot be used besides two actually used spots occurs, quantity of light loss is large, and the S/N ratio fall by quantity of light fall, and when increasing the quantity of light, a laser life will fall.

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[Translation done.]

* NOTICES *



EFFECT OF THE INVENTION

[Effect of the Invention] The objective lens of this invention enables record playback of the optical disk which has substrate thickness which is different by one pickup, and it makes it possible to realize the information pickup easy [ structure ] and compact which has compatibility in mutual [ which suppressed quantity of light loss as much as possible ], and an optical disk unit. although other flux of lights became the unnecessary light which does not contribute for carrying out reading appearance when performing information read-out by the optical spot by the one flux of light since outgoing radiation of two or more flux of lights was always carried out towards an information recording surface and the hologram was arranged -- like There was no defect that the diffracted light which cannot be used besides the actually used spot light occurred, and for this reason, greatly, the S/N ratio fall by quantity of light fall, and when increasing the quantity of light, the defect that a laser life will fall was also able to cancel quantity of light loss.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] This invention cancels the above-mentioned defect, enables record playback of the optical disk which has substrate thickness which is different by one pickup, and aims at obtaining the objective lens for record playback of the optical information record medium which makes it possible to realize the information pickup easy [ structure ] and compact which has compatibility in mutual [ which suppressed quantity of light loss as much as possible ], and an optical disk unit.

[Translation done.]

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MEANS

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[Means for Solving the Problem] An objective lens for record playback of an optical information record medium of this invention It is the objective lens which has positive refractive power which condenses light from the light source on an information recording surface through a transparence substrate of an optical information record medium. One [ at least ] lens side is constituted by three or more zona-orbicularis-like lens sides centering on an optical axis so that this objective lens may condense on an information recording surface about each of two or more kinds of optical information record media which has a transparence substrate with which thickness differs. this -- while a ****** zona-orbicularis-like lens side has different refractive power among three or more zona-orbicularis-like lens sides, a zona-orbicularis-like lens side located in the outermost periphery is characterized by having refractive power corresponding to an optical information record medium with thinnest transparence substrate among two or more optical information record media which have a transparence substrate with which the above-mentioned thickness differs.
[0007] The above-mentioned objective lens is more specifically a positive single lens which turned a convex to a light source side. In a rectangular coordinate system which both sides facing a light source and information recording surface side are the aspheric surfaces, and a zona-orbicularis-like lens side is formed in a field by the side of the light source at least, and this aspheric surface configuration made top-most vertices of a field a zero, and set the X-axis as the direction of an optical axis They are a cone number and Ai about kappa. An aspheric surface coefficient and Pi If it is the number of **** of the aspheric surface It comes, [Equation 2]

$$x=\frac{C\phi^2}{1+\sqrt{1-(1+\kappa)C^2\phi^2}}+\Sigma Ai\phi^{Pi} \quad \cdots ①$$

$$\phi=\sqrt{y^2+z^2}, \quad C=1/r$$

It comes out, and it is expressed and optical-path-length difference ** of the thickness of a lens and the light source wavelength lambda on the shaft at the time of even an optical axis extending the configuration of each zona-orbicularis-like lens side corresponding to the same transparence substrate according to the above-mentioned aspheric surface configuration type satisfy the following relation.
** = mlambda ... **[ **, however ]: Follow the above-mentioned aspheric surface configuration type in the configuration of two zona-orbicularis-like lens sides of the arbitration of each zona-orbicularis-like lens side corresponding to the same transparence substrate, and even an optical axis is. the wavelength of the light source which multiplied the difference of the thickness of the lens on the shaft when extending by the refractive index of this lens in operating wavelength and of which value lambda:use is done -- m is an integer here and the more desirable thing which optical-path-length differences are the following ranges is desirable.
- 10 <= m <= 10 ... It is desirable for the configuration of ** and each zona-orbicularis-like lens side corresponding to the same above-mentioned transparence substrate to be able to express by the same aspheric surface configuration formula.
[0008] In the lens side by the side of the light source which makes the zona-orbicularis-like lens

side configuration of the above-mentioned objective lens, it is desirable for the angle of each **** and optical axis of outside zona-orbicularis-like lens each one in the boundary portion of an adjoining zona-orbicularis-like lens side and inside zona-orbicularis-like lens each one to make to fill the following conditional expression.
theta (2i-1) > theta' (2i) [ -- 1 <=i<=N/2 and i -- integer] ... ** theta (2j) < -- theta' (2j+1) [1<=j<= (N-1)/2 and j -- integer ]-** -- however, N : the number theta of zona-orbicularis-like lens sides of the lens side by the side of the light source of an objective lens (2i-1) It is the angle of the normal of a ** (2i-1) zona-orbicularis-like lens side and optical axis in the boundary portion of 2 i flower band-like lens side to make. the [ a :** (2i-1) zona-orbicularis-like lens side and ] -- a ** (2i-1) zona-orbicularis-like lens side -- the -- it is located outside 2 i flower band-like lens side (circumference side).
theta' (2i) : -- the [ a ** (2i-1) zona-orbicularis-like lens side and ] -- the [ in the boundary portion of 2 i flower band-like lens side ] -- the angle of the normal of 2i zona-orbicularis side, and an optical axis to make -- it is -- the -- 2 i flower band-like lens side is located inside a ** (2i-1) zona-orbicularis-like lens side (optical-axis side).
theta (2j) : -- the -- the [ in the boundary portions of 2 j flower band-like lens side and a ** (2j+1) zona-orbicularis-like lens side ] -- the angle of the normal of 2 j flower band-like lens side, and an optical axis to make -- it is -- the -- 2 j flower band-like lens side is located outside a ** (2j+1) zona-orbicularis-like lens side (circumference side).
theta'(2j+1): -- the -- the angle of the normal of a ** (2j+1) zona-orbicularis-like lens side and optical axis in the boundary portions of 2 j flower band-like lens side and a ** (2j+1) zona-orbicularis-like lens side to make -- it is -- a ** (2j+1) zona-orbicularis-like lens side -- the -- it is located inside 2 j flower band-like lens side (optical-axis side).
[0009] As for the above-mentioned objective lens, it is still more desirable that the boundary of an outermost periphery zona-orbicularis-like lens side and the zona-orbicularis-like lens side of the one inside is set up so that the following conditional expression may be satisfied.
1.50 < -- Lambda/NA 2 < -- 2.00 ... ** -- however -- Lambda : Wavelength (Micrometer) of Light Source to be Used
NA2 : several zona orbicularis desirable [ it ] and formed [ one place of the numerical aperture of the flux of light which carries out outgoing radiation from the zona-orbicularis-like lens side inside / one / the outermost periphery, and the boundary portion between each zona-orbicularis-like lens side did not have a level difference, and ] in the lens side by the side of the light source -- N -- 3<=N<=10 ... -- ** -- further -- desirable -- 3<=N<=6 ... -- it is desirable that it is in the range of **
[0010] The material which forms the above-mentioned objective lens may be glass, or may be plastics.

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[Translation done.]

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OPERATION

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[Function] The objective lens for record playback of the optical information record medium of this invention enables record playback of the optical disk with which the thickness of a transparence substrate differs, when one [ at least ] lens side consists of zona orbicularis which has the refractive power from which a ****** zona-orbicularis-like lens side differs and condenses the flux of light on each information recording surface through the transparence substrate with which the thickness of an optical information record medium differs. When the parallel flux of light with a wavelength of 635nm carries out incidence of drawing 3 on condition that NA 0.60, 0.6mm of substrate thickness, and the substrate refractive index 1.58, it is optical-path drawing when carrying out incidence of the flux of light to the objective lens with which aberration amendment was optimized. When the parallel flux of light with a wavelength of 635nm carries out incidence of drawing 4 on condition that NA 0.38, 1.2mm of substrate thickness, and the substrate refractive index 1.58, it is optical-path drawing when carrying out incidence of the flux of light to the objective lens with which aberration amendment was optimized. Drawing 5 is optical-path drawing when carrying out incidence of the flux of light to the objective lens which has the refracting interface of the shape of zona orbicularis which has drawing 3 and two conditions in 4. After the flux of light from infinite distance passes drawing, incidence of it is carried out to the objective lens which has a zona-orbicularis-like lens side. It is divided into the substrate thickness of 0.6mm, and two spots which condense through 1.2mm by passing through the zona-orbicularis-like lens side where refractive power differs here.
[0012] The outgoing beam from the inside zona orbicularis including an optical axis shows the case where it is constituted so that it may condense through 1.2mm of substrate thickness so that drawing 5 may form in the lens side of an objective lens two zona-orbicularis-like lens sides (only henceforth the zona orbicularis) where refractive power differs and the outgoing beam from the periphery zona orbicularis may condense through 0.6mm of substrate thickness. In the case of this example, the optical intensity distribution of the flux of light which condenses through 0.6mm of substrate thickness and 1.2mm of substrate thickness come to be shown in drawing 6 and 7, respectively. Since the optical spot from the periphery zona orbicularis which condenses through the substrate of 0.6mm of substrate thickness is a spot for making it correspond to high density information record, when the reinforcement of a side lobe as shown in drawing 6 becomes large too much, it causes increase of a noise and a ****** case is in record playback of high density information about a bad influence. Therefore, by considering as the 3rd zona orbicularis which has the refractive power corresponding to 0.6mm of substrate thickness for an inner circumference side including the optical axis of the inner circumference zona-orbicularis section corresponding to 1.2mm of substrate thickness, at the time of 0.6mm of substrate thickness, the area of the 2nd zona orbicularis which carries out outgoing radiation of the unnecessary light can be decreased, and a side lobe can be decreased. It becomes possible to obtain two optical spots suitable for performing record playback of the optical information record medium with which substrate thickness differs by constituting from a periphery two or more zona orbicularis from which the refractive power which repeats this, namely, is prepared in a lens side differs alternately. however, the level which is satisfactory practically in a side lobe since the width of face of the zona orbicularis will become small too much and processability will worsen, if the number of zona orbicularis is increased too much -- mitigating -- in addition -- and in order to keep processability good, it is desirable to make it three or more zona orbicularis and ten zona orbicularis or less. It is desirable to make it three or more zona orbicularis

and six zona orbicularis or less still more desirably.

[0013] By making the light source side of an objective lens into a convex, and introducing the aspheric surface into both sides by the side of the light source and an information recording surface further, a single lens can realize an objective lens and cost reduction becomes possible. When the thickness of the lens on the shaft at the time of even an optical axis extending the lens side configuration of each zona orbicularis corresponding to the same transparence substrate according to the above-mentioned ** type is not equal, an optical-path-length difference arises in the flux of light which passes each zona orbicularis. When the wave faces which have an optical-path-length difference overlap, interference occurring is known well, and when the relation of **=mlambda (m is an integer) is materialized between optical-path-length difference ** and wavelength lambda, the reinforcement by interference serves as max. Therefore, when conditional-expression ** is materialized between value ** which applied the refractive index of the lens in operating wavelength to the difference of the thickness of the lens on the shaft at the time of even an optical axis extending the lens side configuration of two zona orbicularis of the arbitration of each zona orbicularis corresponding to each transparence substrate according to the above-mentioned ** type, and the operating wavelength lambda, the optical spot of the maximum reinforcement will be obtained. However, since there is specifically wavelength variation by the light source, the variation by individual difference, and the temperature change in the wavelength of semiconductor laser, it is difficult to fix to fixed wavelength. Therefore, the case where the relation of optical-path-length difference conditional-expression ** collapses from each zona orbicularis to the flux of light arises. Since it generates about 5%, such wavelength variation is good to satisfy conditional-expression ** more desirably. In this case, even if wavelength variation arises, it is possible to maintain 50% or more of reinforcement of original reinforcement. Furthermore, if it is **=0, it cannot be overemphasized irrespective of wavelength variation that fixed reinforcement is maintainable. Moreover, in order to raise the processability of this zona orbicularis more, it is desirable for the configuration of these zona orbicularis to be able to express by the same aspheric surface configuration formula.

[0014] As a material of an objective lens, it is also possible to use any of glass and plastics. In the case of a glass material, it becomes possible [ realizing low cost further by using a plastics material ], when an engine-performance change the thing with little engine-performance change for which the stable lens is offered is possible, and according to an environmental variation is permissible to an environmental variation.

[0015] When not filling conditional-expression ** and **, the location of the optical spot which condenses through each of a thin transparence substrate and a thick transparence substrate will approach. If the location of two optical spots approaches, the optical reinforcement in the information recording surface of an unnecessary optical spot will become large. Consequently, a big noise will occur and record playback of an optical information record medium becomes difficult.

[0016] This invention tends to realize record playback of the record medium with which the thickness of a transparence substrate differs with a single objective lens in the trend of the recent years of an optical information record medium like the thin high density information record disk of substrate thickness, and the conventional disk. For example, since the disk of 0.6mm of substrate thickness aims at densification, a small optical spot is called for compared with the conventional CD of 1.2mm of substrate thickness, and CD-ROM. Specifically in the conventional CD, CD-ROM, etc., the optical spot whose NA of an objective lens the wavelength of the light source is about 0.45 in 780nm was called for. The magnitude of an optical spot is proportional to wavelength, and it is known well that it is in inverse proportion to NA. Therefore, in order to make an optical spot small, it is necessary to shorten wavelength or to enlarge NA of an objective lens. In the high-density disk of 0.6mm of substrate thickness, while shortening wavelength of the light source to 635nm - about 650nm, it considers making an optical spot small by making NA of an objective lens large to about 0.6.

[0017] In realizing the optical spot corresponding to two kinds of disks from which the thickness of a transparence substrate differs with the objective lens of this invention, 0.6mm of substrate thickness, and 1.2mm of substrate thickness, it distributes to the flux of light for disks of 0.6mm of substrate thickness, and 1.2mm of substrate thickness every other one from the zona orbicularis of the

outermost periphery. Therefore, when the wavelength of the light source is 635nm, it is necessary to use as an optical spot equivalent to NA0.6 the flux of light which passed the zona orbicularis of the outermost periphery, and to use as an about (equivalent to about 0.45 NA, when light source wavelength is 780nm) 0.37-NA optical spot the flux of light which passed the zona orbicularis of the one inside. Conditional-expression ** is required in order to fulfill this condition. In fixed light source wavelength, if it becomes so small that the numerical aperture NA2 of the zona orbicularis of the one inside exceeds a maximum from the outermost periphery, an optical spot will become large too much and record playback of the optical information record medium of 1.2mm of substrate thickness will become difficult. Moreover, if numerical aperture NA2 becomes large so that a minimum is exceeded, an optical spot will become small too much and informational record playback will become difficult too.

[0018] the objective lens of this invention has the equal thickness of the lens on the shaft at the time of even an optical axis extending the lens side configuration of each zona orbicularis which two or more kinds of transparence substrates are alike , respectively , and corresponds according to ** type , or when there is a difference , it is setting to one of the features trying for the optical path length difference produce by it to serve as an integral multiple of use light wave length . Moreover, the lens side where refractive power differs is made to adjoin in the shape of zona orbicularis. Therefore, on all the boundaries of the zona orbicularis which recognizes individual (N-1) existence in the lens side which has the zona orbicularis of N individual, it is difficult to make it the continuous field without a level difference. However, if a level difference is in a lens side, since it will become easy to generate a chip etc. into a level difference portion, in respect of productivity and processability, a level difference is not desirable. Therefore, in order to raise productivity and processability, as for one place of the boundary section between zona orbicularis, it is desirable that it is a field [ **** ] without a level difference.

[0019] Hereafter, the example of the objective lens of this invention is shown. Both the examples 1 and 2 are infinity conjugation mold objective lenses, and the incident light to an objective lens is the parallel flux of light. Moreover, operating wavelength is 635nm. The cross section and optical-path drawing of an example 1 are shown in drawing 1 , and the cross section and optical-path drawing of an example 2 are shown in drawing 2 . Drawing is made into the 1st page in each example, and it is [ radius of curvature / of the i-th field ] ni from here to order about the refractive index in the light source wavelength of the medium between di, the i-th field, and the i+1st fields in the thickness on ri and the i-th optical axis of a field and the i+1st fields, and a gap. It expresses. Moreover, the refractive index of air is set to 1. Moreover, the aspheric surface configuration has written each data with the configuration where even the optical axis extended each zona-orbicularis-like lens side by ** type in the lens side which makes a zona-orbicularis configuration.

[0020] Example 1 Light source side : Division 3 zona orbicularis (from the periphery of a lens side to the 1st, 2nd, and 3rd zona orbicularis)

The zona-orbicularis [ 1st ] outside diameter: 4.08 The 1st zona-orbicularis numerical aperture NA 1:0.60 The zona-orbicularis [ 2nd ] outside diameter: 2.84 The 2nd zona-orbicularis numerical aperture NA 2:0.38 The zona-orbicularis [ 3rd ] outside diameter: 1.20 The 3rd zona-orbicularis numerical aperture NA 3:0.18 Disk side: The 1st and 3rd zona orbicularis of community (thin substrate correspondence)

i ri di ni 1 Drawing (infinity) 0.00 1.00 2 2.062 2.60 1.49005 3 -5.078 1.61 1.00 4 infinity 0.60 1.58000 Five recording surfaces (infinity)

The 2nd zona orbicularis (thick substrate correspondence)

i ri di ni 1 Drawing (infinity) 0.0627 1.00 2 2.340 2.5373 1.49005 3 -5.078 1.61 1.00 4 infinity 1.20 1.58000 5 Recording surface (infinity)

Aspheric surface data The 2nd page The 1st and 3rd zona orbicularis kappa = [ -0.83962 ] A1 = 0.44559x10-2 P1= 4.0000 A2 = 0.23840x10-3 P2= 6.0000 A3 = 0.66596x10-5 P3= 8.0000 A4 =-0.77995x10-5 P4=10.0000 The 2nd zona orbicularis kappa = [ -0.58070 ] A1 = 0.18785x10-2 P1= 4.0000 A2 =-0.15721x10-5 P2= 6.0000 A3 =-0.49050x10-4 P3= 8.0000 A4= 0.36035x10-5 P4=10.0000 The 3rd page kappa =-0.17696x102 A1 = 0.99680x10-2 P1= 4.0000 A2 =-0.44437x10-2 P2= 6.0000 A3 = 0.92652x10-3 P3= 8.0000 A4 =-0.81284x10-4 P4=10.0000 Angle which a normal and an optical axis make theta 1 = 37.8 degrees theta2'=34.1 degree theta2 =14.7 degree

theta3'=16.5 degree[0021] Example 2 Light source side : Division 5 zona orbicularis (the 1st from the periphery of a lens side, the 2nd, the 3rd, the 4th, the 5th zona orbicularis)
The zona-orbicularis [ 1st ] outside diameter: 4.08 The 1st zona-orbicularis numerical aperture NA 1:0.60 The zona-orbicularis [ 2nd ] outside diameter: 2.84 The 2nd zona-orbicularis numerical aperture NA 2:0.38 The zona-orbicularis [ 3rd ] outside diameter: 2.20 The 3rd zona-orbicularis numerical aperture NA 3:0.32 The zona-orbicularis [ 4th ] outside diameter: 1.20 The 1st zona-orbicularis numerical aperture NA 1:0.16 The zona-orbicularis [ 5th ] outside diameter: 0.70 The 2nd zona-orbicularis numerical aperture NA 2:0.10 Disk side: The 1st, 3rd, and 5th zona orbicularis of community (thin substrate correspondence)
i ri di ni 1 Drawing (infinity) 0.00 1.00 2 2.062 2.60 1.49005 3 -5.078 1.61 1.00 4 infinity 0.60 1.58000 Five recording surfaces (infinity)
The 2nd and 4th zona orbicularis (thick substrate correspondence)
i ri di ni 1 Drawing (infinity) 0.0627 1.00 2 2.340 2.5373 1.49005 3 -5.078 1.61 1.00 4 infinity 1.20 1.58000 5 Recording surface (infinity)
Aspheric surface data The 2nd page The 1st, 3rd, and 5th zona orbicularis kappa = [ -0.83962 ] A1 = 0.44559x10-2 P1= 4.0000 A2 = 0.23840x10-3 P2= 6.0000 A3 = 0.66596x10-5 P3= 8.0000 A4 =-0.77995x10-5 P4=10.0000 The 2nd and 4th zona orbicularis kappa=-0.58070 A1 = 0.18785x10-2 P1= 4.0000 A2 =-0.15721x10-5 P2= 6.0000 A3 =-0.49050x10-4 P3= 8.0000 A4= 0.36035x10-5 P4=10.0000 The 3rd page kappa =-0.17696x102 A1 = 0.99680x10-2 P1= 4.0000 A2 =-0.44437x10-2 P2= 6.0000 A3 = 0.92652x10-3 P3= 8.0000 A4 =-0.81284x10-4 P4=10.0000 Angle which a normal and an optical axis make theta 1 = [ 37.8 degrees ] theta2'=34.1 degree theta2 =26.7 degree theta3'=29.8 degreetheta3 = 16.5 degrees theta4'=14.7degree theta4 = 8.6degree theta5'= 9.7 degrees

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[Translation done.]

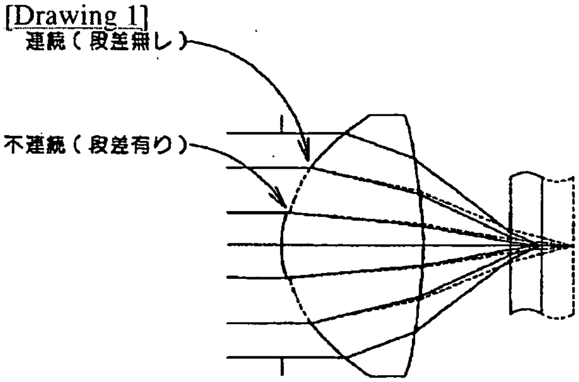
## DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] They are the cross section of the example 1 of the objective lens for record playback of the optical information record medium which has the refracting interface of the shape of zona orbicularis of this invention, and optical-path drawing.
[Drawing 2] They are the cross section of the example 2 of the objective lens for record playback of the optical information record medium which has the refracting interface of the shape of zona orbicularis of this invention, and optical-path drawing.
[Drawing 3] When substrate thickness is 0.6mm, it is optical-path drawing of the objective lens with which aberration amendment was optimized.
[Drawing 4] When substrate thickness is 1.2mm, it is optical-path drawing of the objective lens with which aberration amendment was optimized.
[Drawing 5] Substrate thickness is optical-path drawing of 2 zona-orbicularis lens with which aberration amendment was optimized corresponding to 0.6mm and 1.2mm.
[Drawing 6] Thickness with 2 zona-orbicularis lens is optical intensity-distribution drawing showing one example of the condensing spot through the substrate which is 0.6mm.
[Drawing 7] Thickness with 2 zona-orbicularis lens is optical intensity-distribution drawing showing one example of the condensing spot through the substrate which is 1.2mm.
[Drawing 8] It is the optical plot plan showing one example of the optical system for record playback of the conventional optical information record medium.
[Drawing 9] It is the graph which shows the relation between the transparence substrate thickness of an optical information record medium, and spherical aberration.
[Description of Notations]
1 Light Source 2 Beam Splitter 3 Collimator Lens
5 10 It extracts. 6 11 Objective lens 7 Transparence substrate
8 Information Recording Surface 9 Light-receiving Means

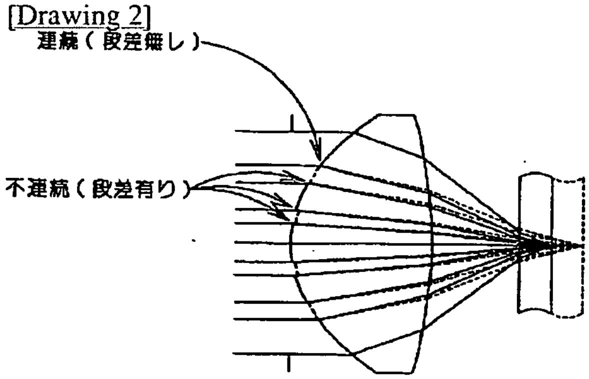
[Translation done.]

DRAWINGS

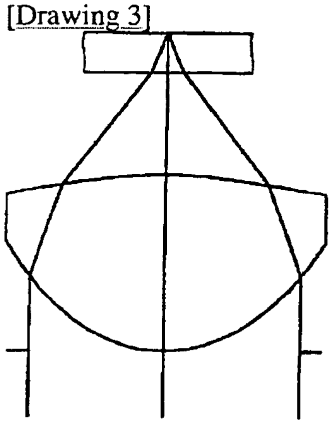
[Drawing 1]



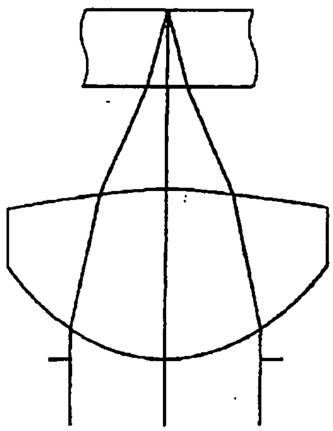

[Drawing 2]



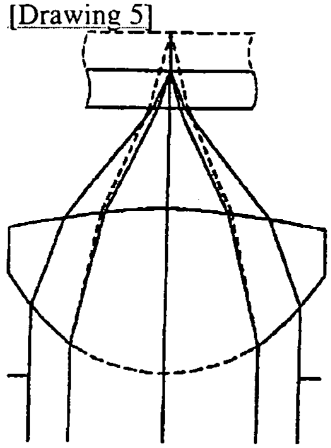

[Drawing 3]



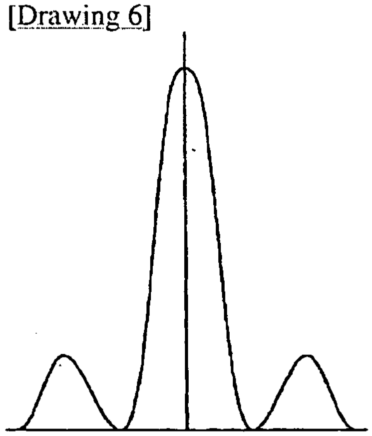
[Drawing 4]



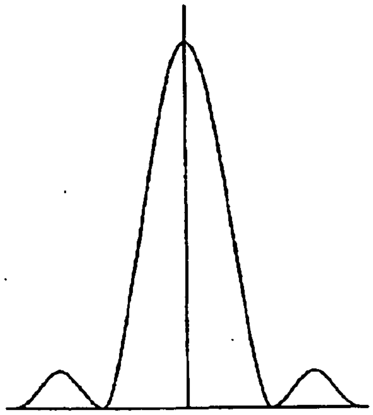
[Drawing 5]



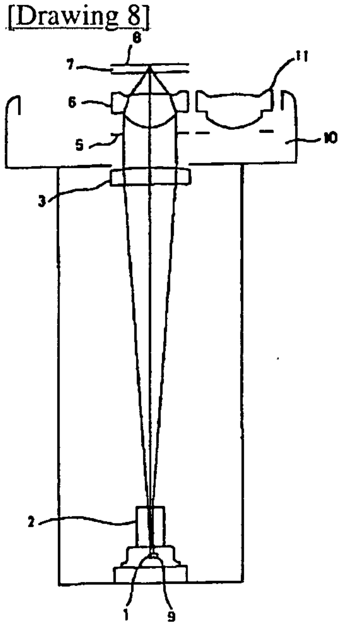
[Drawing 6]



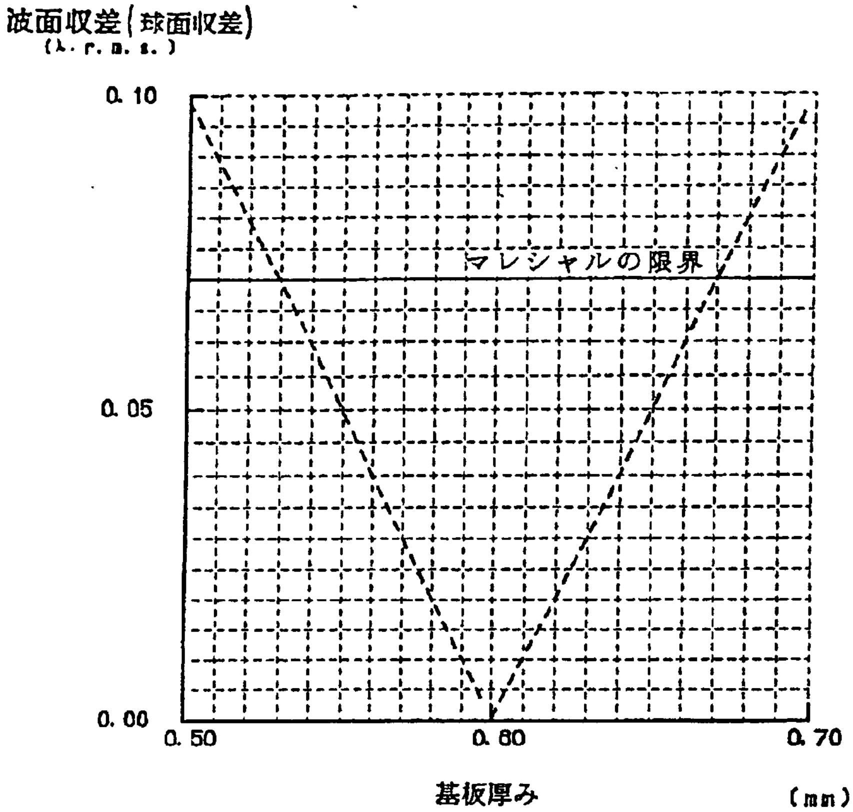
[Drawing 7]



[Drawing 8]




[Drawing 9]




[Translation done.]